United States Patent [19]

Whipple

[11] **Patent Number:** 4,496,122

[45] **Date of Patent:** Jan. 29, 1985

[54] **EXTENDED MOMENT ARM ANTI-SPIN DEVICE**

[75] Inventor: **Raymond D. Whipple,** Newport News, Va.

[73] Assignee: **The United States of America as represented by the Administrator of the National Aeronautics and Space Administration,** Washington, D.C.

[21] Appl. No.: **508,371**

[22] Filed: **Jun. 27, 1983**

[51] **Int. Cl.**^{3} **B64C 17/00**

[52] **U.S. Cl.** .... **244/75 R;** 244/139; 244/147

[58] **Field of Search** .... 244/138 R, 139, 147, 244/75 R, 113, DIG. 1

[56] **References Cited**

U.S. PATENT DOCUMENTS

1,331,705	2/1920	Greenfield	244/147
1,433,395	10/1922	Marshall .	
1,457,044	5/1923	Sherry .	
1,972,967	9/1934	Zahodiakin	244/139
2,411,077	11/1946	Andreopoulos et al. .	
2,433,952	1/1948	Hines .	
2,972,457	2/1961	Steinthal .	
3,058,702	10/1962	Sharples et al. .	
3,129,912	4/1964	Smith .	
3,362,289	1/1968	Guin .	
3,419,234	12/1968	Poirier .	
3,930,628	1/1976	Robelen	244/139
4,040,583	8/1977	Bihrle .	
4,108,402	8/1978	Bowen	244/147

FOREIGN PATENT DOCUMENTS

2069425	8/1981	United Kingdom .

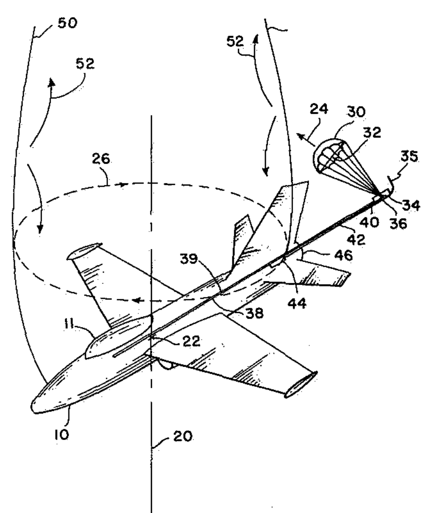
Primary Examiner—Galen L. Barefoot

Attorney, Agent, or Firm—Howard J. Osborn; John R. Manning

[57] **ABSTRACT**

A device which corrects aerodynamic spin wherein a collapsible boom **42** extends an aircraft moment arm and an anti-spin parachute force **24** is exerted upon the end of the moment arm to correct intentional or inadvertent aerodynamic spin. This configuration effects spin recovery by means of a parachute **30** whose required diameter **32** decreases as an inverse function of the increasing length of the moment arm. The collapsible boom **42** enables the parachute **30** to avoid the aircraft wake **50** without mechanical assistance, retracts to permit steep takeoff, and permits a parachute **30** to correct spin while minimizing associated aerodynamic, structural and in-flight complications.

4 Claims, 5 Drawing Figures



4,496,122

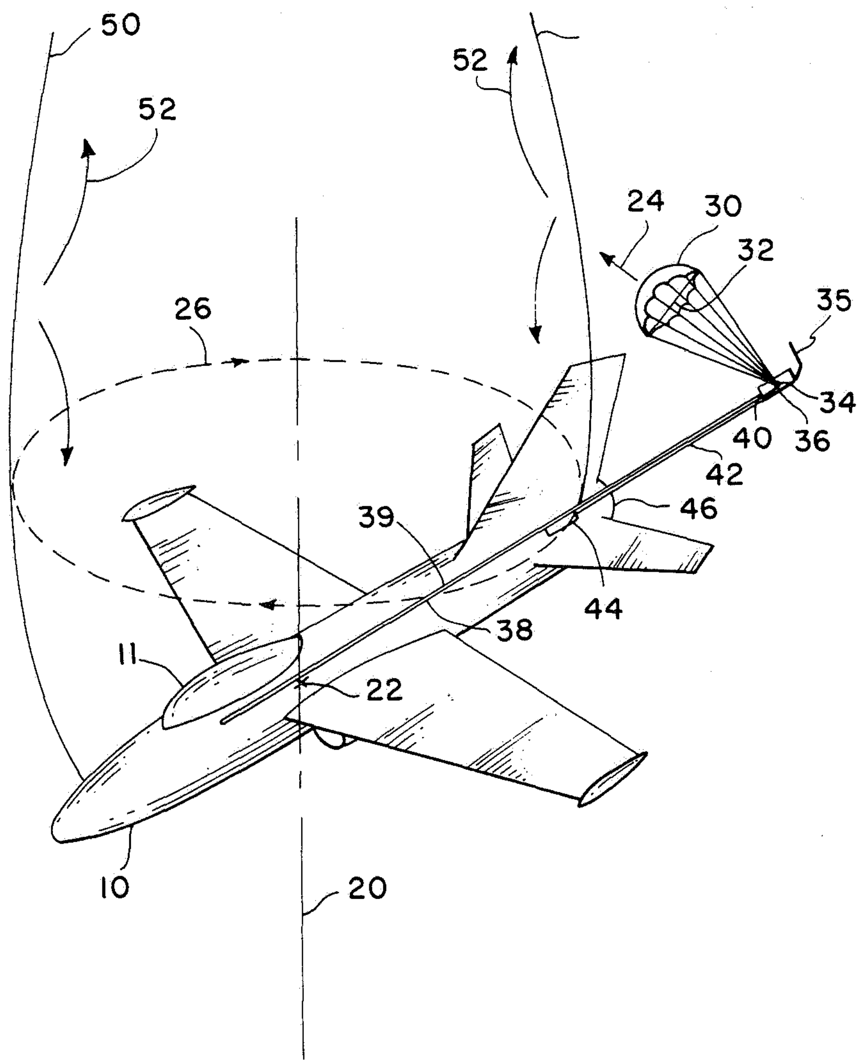


FIG. 1

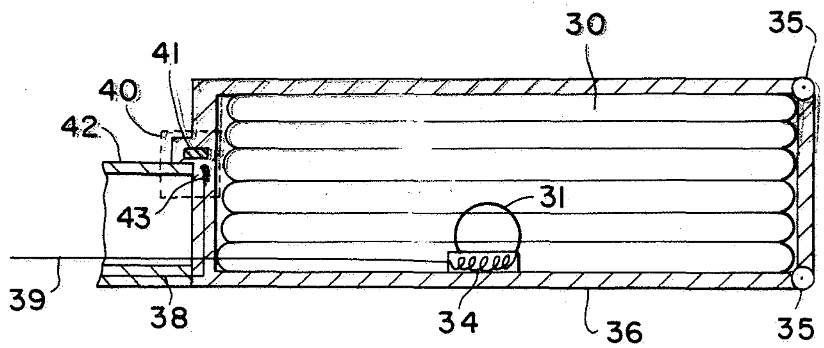


FIG. 2

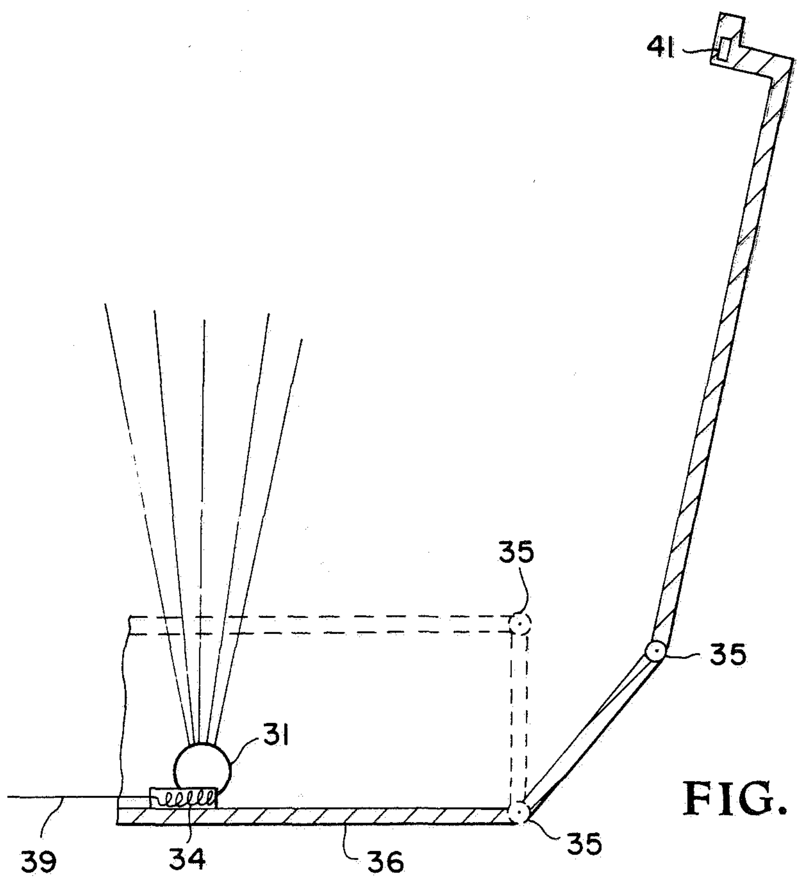


FIG. 3

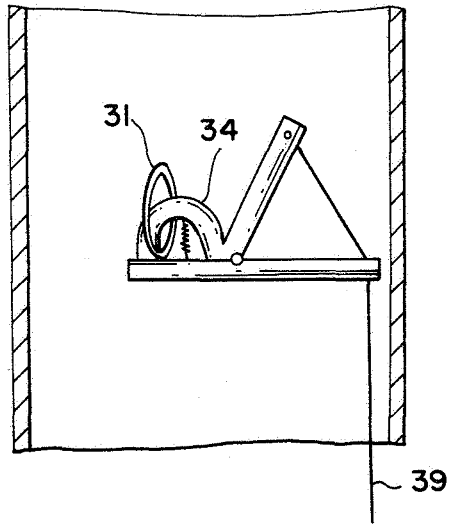


FIG. 4

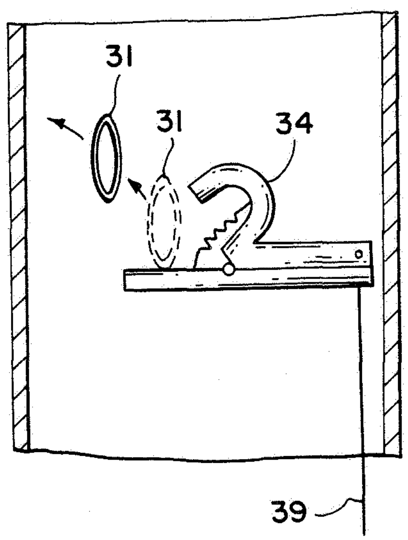


FIG. 5

EXTENDED MOMENT ARM ANTI-SPIN DEVICE

ORIGIN OF THE INVENTION

The invention described herein was made by an employee of the United States Government and may be used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

INTRODUCTION

Military aircraft are routinely tested to identify the types of spins which might be encountered during operational flights. The spin most difficult to correct is the flat spin, in which the aircraft rotates about its center of mass in a somewhat nose down position which approaches the horizontal "spinning top" configuration. In the event that ordinary aerodynamic controls are inadequate to stop the spin, an anti-spin parachute (or other anti-spin force) provides emergency correction.

The present invention was developed to permit equivalent correction of flat spins as accomplished by existing devices, but which would also maximize flight test accuracy, safety, efficiency and structural simplicity of the anti-spin parachute and its associated aircraft.

BACKGROUND OF THE INVENTION

With prior art arrangements, flat spins were commonly corrected by a parachute deployed from the rear of the aircraft. The parachute created an anti-spin torque by exerting a force, opposite to the spin, through the moment arm extending from the aircraft center of mass to the point of chute attachment. These anti-spin parachutes were frequently installed for use during flight testing of the aircraft, but their installation not only introduced error into the results of those flight tests, but created so many design problems that the chutes were seldom incorporated into operational fighter or commercial planes. The large diameter parachutes and long towlines required stowage compartments in the rear fuselage, and the compartments produced undesirable deviations from the production contours of the aircraft. The large chute forces, in addition, required substantial structural reinforcement of the aircraft to enable it to withstand the high design load of the chute, and such reinforcements altered the mass distribution of the aircraft and its subsequent flight test performance.

Conventional rear deployed anti-spin parachutes created three other problems as well. The parachutes required mechanisms, usually pyrotechnic, to eject the chute beyond the wake of the spinning aircraft. All of these mechanisms required special attention and the explosive devices were potentially unsafe. In addition, even when properly functional, the devices did not prevent the chute from re-entering the wake and such re-entry caused partial or total parachute collapse. Finally, the chutes created so much drag that flight after spin recovery was impossible as long as the chute was in place, and redundant mechanisms to ensure chute release were required.

OBJECTS OF THE INVENTION

Accordingly, it is an object of the present invention to provide a fixed or retractable structure anchored to the aircraft, the function of which is to provide an extended moment arm through which a parachute or other device may exert its anti-spin torque.

Another object of the invention is to provide a means whereby equivalent spin correction may be accomplished by a parachute whose required diameter decreases as an inverse function of the increasing length of the moment arm, wherein the diameter is less than one-half of the diameter that would be necessary were the parachute attached to the rear of the fuselage.

A further object of the invention is to provide a means for correcting spin which incorporates a parachute, the size of which will minimize or eliminate need for a stowage compartment whose dimensions alter the production contours of the aircraft.

Still another object of the invention is to provide a means for correcting spin which incorporates a parachute, the chute load of which will minimize or eliminate the necessity of structural reinforcement of the aircraft.

Yet another object of the invention is to provide a means for correcting spin which incorporates a parachute, the chute drag of which will not make further aircraft operation impossible in the event of misfunction of the parachute release mechanism, thus eliminating the necessity of redundant parachute release mechanisms.

A further object of the invention is to provide a retractable mechanism for correcting spin which may be partially or totally housed within the rear fuselage in order to preserve the aerodynamic design of the aircraft and to permit unimpeded rotation upon steep takeoff.

A still further object of the invention is to provide extended means from which the anti-spin parachute is deployed, permitting deployment of the parachute exterior to the wake of the spinning aircraft without necessity of additional means, pyrotechnic or otherwise, to avoid the aircraft wake.

Yet another object of the invention is to provide a mechanism to maintain inflation of the parachute by preventing its re-entry into the aircraft wake.

A still further object of the invention is to provide a parachute of a size simultaneously appropriate for use as an anti-spin parachute and as a drag parachute (decelerating device).

The foregoing and additional objects are attained by providing a device to correct aerodynamic flat spin comprising an extension of the moment arm of the aircraft permitting an associated force, such as a parachute, to exert its anti-spin torque on the aircraft by means of the extended moment arm. This configuration permits equivalent spin correction with a parachute whose required diameter decreases as an inverse function of the increasing length of the moment arm. The extension enables the parachute to avoid the aircraft wake without mechanical assistance, retracts to permit steep takeoff, and permits a parachute to correct spin while minimizing associated aerodynamic, structural and in-flight complications.

Other objects and advantages of the present invention will be more readily apparent to those skilled in the art as the same becomes better understood with reference to the following description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the invention in which the parachute is shown exerting its force opposite to the direction of the spin;

FIG. 2 is a cross-sectional view of the parachute housing before parachute deployment;

FIG. 3 is a cross-sectional view of the parachute housing after parachute deployment;

FIG. 4 is an elevational view of the spring clamp in a closed position before parachute release; and

FIG. 5 is an elevational view of the spring clamp in an open position after parachute release.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings and initially to FIG. **1**, a test aircraft **10** has intentionally or inadvertently encountered an aerodynamic spin; the descending aircraft rotates about the vertical spin axis **20** through the aircraft center of mass **22**. The invention permits a parachute force **24** to act through a collapsible boom **42** to oppose the direction of spin **26** to allow the pilot to recover and resume normal flight. The preferred embodiment of the invention includes a nylon parachute **30** of a diameter **32**, releasably attached to a spring clamp **34** within parachute housing **36**. FIG. **2** illustrates a cross-section of the parachute housing **36**, prior to parachute deployment, which consists essentially of a four-sided aluminum box housing the parachute **30**; the box is open on two sides and hinged at each of its upper and lower outboard edges by housing hinges **35**. The spring clamp **34** is anchored to the parachute housing **36** and clamps through the parachute ring **31** to secure it. A parachute housing latch area **40** contains the mechanism by which the parachute housing **36** is latched or unlatched. The parachute housing latch area **40** includes a magnetic plate **41** embedded in the lid of parachute housing **36**; the magnetic plate is positioned opposite to an electromagnet **43** whose current is supplied via housing latch control line **38**. The electromagnet **43** remains inactivated throughout ordinary aircraft operation, but may be energized from the cockpit **11**, in the event of spin, by the connecting parachute housing control line **38**. The process whereby the parachute housing **36** is unlatched is described in Operation below. Because the electromagnet **43** initially has no charge, the magnetic plate **41** attracts the steel surface of the electromagnet **43** to hold parachute housing **36** in its initial closed position. FIG. **3** is a partial illustration of the parachute housing **36** in its open position.

Referring again to FIG. **1**, the collapsible boom **42** extends beyond the rear fuselage **46** to support the parachute housing **36**; the boom **42** supports the parachute housing **36** and provides protection for those sections of housing latch control line **38** and parachute release line **39** which extends beyond the aircraft **10**. The parachute release line **39** connects the spring clamp **34** to the cockpit **11** in order that the parachute ring **31** may be selectively held in place. The collapsible boom **42** is rigid when fully extended, but is retractable by means of the retraction/stowage mechanism **44** located within the rear fuselage. Representative structure of a collapsible boom and retraction/stowage mechanism **44** is disclosed in U.S. Pat. No. 4,259,825, to Hedgepeth et al, in which a foldable beam is extended from and retracted to a cylindrical repository. When extended, collapsible boom **42** extends beyond the aircraft wake **50**, said wake resulting from the aggregate local air flows **52** created above the aircraft by the spin.

The structure of the alternate embodiment of the invention differs only in that retraction/stowage mechanism **44** is omitted and boom **42** is rigid in construction and fixed directly to the rear fuselage of the aircraft **10**. Parachute **30**, parachute housing **36** and all associated control devices are identical to those of the preferred embodiment of the invention.

OPERATION

Under normal circumstances, aircraft **10** operates without need of an emergency anti-spin device. For this reason, during ordinary flight, collapsible boom **42** is maintained in its collapsed state and stored by means of retraction/stowage mechanism **44** (FIG. **1**). Parachute **30** is packed within parachute housing **36** and parachute housing latch area **40** is firmly secured due to the attraction of the magnetic plate **42** for the uncharged electromagnet **43** (FIG. **2**). In the event that the aircraft encounters an aerodynamic spin, the pilot extends the collapsible boom **42** (FIG. **1**) by activating the retraction/stowage mechanism **44**. After boom **42** is fully extended, the pilot activates the electromagnet **43** by means of housing latch control line **38** to create an electromagnet **43** like in polarity to the magnetic plate **41**. As shown in FIGS. **2** and **3**, the like polarities repel each other and the parachute housing **36** opens. The freestream air continues to open parachute housing **36** by rotating housing hinges **35**. The freestream air also inflates the parachute **30**. As the parachute inflates, it exerts a parachute force **24** opposite to the direction of the spin **26** (FIG. **1**), thus correcting the spin. After the spin is corrected, the pilot releases the parachute **30** by opening the spring clamp **34** via parachute release line **39** to release parachute ring **31** as shown in FIGS. **4** and **5**. No redundant release mechanism is provided; the parachute **30** does not create sufficient drag to prevent further aircraft flight in the event that the release of parachute **30** becomes impossible. The boom **42** is not retracted until after landing; any test or operational aircraft, which has just recovered from an emergency spin situation will almost invariably land promptly, obviating the necessity for the in-flight retraction of the boom. As the aircraft **10** is readied for its next flight, the parachute **30** is repacked into parachute housing **36**, the inactivated electromagnet **43** is recoupled with magnetic plate **41**, and boom **42** is retracted into the rear fuselage **46**.

Operation of the alternate embodiment of the invention is identical to the preferred embodiment except that rigid boom **42** is fixed to the rear fuselage and is neither extended before spin correction nor retracted after landing. Parachute **30** and all associated structures operate as described above.

The present invention extends the moment arm through which a parachute or other device exerts its anti-spin force. The moment arm of a conventional anti-spin parachute extends from the aircraft center of mass **22** to the tip of rear fuselage **46**; the extended moment arm of the present invention originates at the aircraft center of mass **22**, but extends the length of collapsible boom **42** to its termination at spring clamp **34**. The collapsible boom, therefore, extends the moment arm by an amount approximately equal to its own length and permits a relatively smaller parachute to exert the same anti-spin torque as a conventional rear-deployed parachute.

The effectiveness of the present invention is best illustrated by actual comparison of its chute load with that required by a conventional anti-spin parachute. The actual embodiment of the invention described above accomplished spin recovery in 13 turns of the

aircraft; a conventional anti-spin parachute accomplished recovery in 14 turns but entailed more than seven times the calculated parachute load as did the present invention. The dimensions and calculations for each respective device are provided below.

The test model of the preferred embodiment of the invention included a fighter aircraft with a distance from the center of mass to the tip of the rear fuselage of 22 ft.; the collapsible boom measured 9 ft. after full extension and increased the parachute moment arm to 31 ft. The 9.4 ft. parachute diameter determined the chute force by the equation $F=C_DqS$, where F is the parachute load or force, C_D is the drag coefficient of the specific Nylon parachute employed, q is the freestream velocity of the descending aircraft and S is the parachute area calculated by one-half diameter$^2\pi$. Under actual test conditions, the 9.4 ft. diameter parachute exerted a calculable force of 3100 lbs. The invention exerted an anti-spin torque, therefore, of 3100 lbs.×31 ft., or 96,100 ft-lbs., and spin recovery was complete after 13 turns of the aircraft.

The conventional anti-spin parachute accomplished spin recovery in 14 aircraft turns and comprised a fighter aircraft with a distance from the center of mass to the tip of the rear fuselage of 22 ft.; the parachute was attached to the tip of the rear fuselage by means of a nylon cord 74 ft. long. The parachute diameter was 26 ft. and the calculated chute load was 23,500 lbs. under identical test conditions. The parachute, therefore, created a torque of 23,500 lbs.×22 ft., or 517,000 ft-lbs.—approximately 5 times as much torque as was necessary with the present invention for a substantially equivalent spin recovery.

The relatively smaller parachute force of the present invention minimizes chute load on the structural components of the aircraft and reduces or eliminates the necessity of structural reinforcements. The lesser chute drag does not make further flight impossible in the event of failure of the parachute release mechanism of the spin correction. The smaller parachute has a smaller surface area and requires less storage space than did the conventional spin chutes and their long flexible towlines; the smaller chute minimizes or eliminates the need for bulky stowage compartments which alter the production contours of the aircraft.

The invention deploys the parachute outside of the aircraft wake and keeps it from collapsing back into the wake; the lengthened moment arm permits a relatively smaller parachute to accomplish equivalent spin recovery. Finally, whereas conventional spin chutes are generally employed only on test aircraft, any aircraft equipped with the present device as its drag chute will

automatically be equipped with an anti-spin parachute as well.

Various changes may be made in the shape, size and arrangement of parts without departing from the spirit or scope of the invention. For example, a device other than a parachute may be installed at the outboard end of the rigid boom if such a device is capable of creating an effective anti-spin force. In addition, a parachute with a flexible towline of a suitable length can be deployed from the rigid boom in the same manner as the simple parachute shown in FIG. 1. These and other applications of the present invention will be readily apparent to those skilled in the art in light of the above teachings. It is therefore to be understood that the invention may be practiced otherwise than as specifically described and claimed herein.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A device which corrects aerodynamic spin during aircraft operation comprising:
   - an aircraft;
   - extendable boom means housed completely within the aircraft;
   - said extendable boom means forming an extension of an anti-spin moment arm of said aircraft when extended from the tail of the aircraft;
   - parachute means carried by said extendable boom means at the end thereof remote from the aircraft;
   - means for deploying said parachute means for exerting an anti-spin force at the end of said moment arm;
   - said parachute means having a diameter and said extendable boom means having a length permitting relative reduction in parachute size necessary to accomplish spin correction and continued flight of the aircraft without release of the parachute means.

2. The combination as in claim 1 wherein said extendable boom means includes means for extending and retracting whereby preservation of the aerodynamic design of the aircraft is maximized.

3. The combination as in claim 1 wherein said parachute means is of a diameter determined as an inverse function of the total length of the moment arm, whereby a longer moment arm permits a relative reduction in the chute size necessary to accomplish equivalent spin correction.

4. The combination as in claim 1 wherein said extendable boom means is a rigid boom, said boom extending and maintaining said parachute means beyond the wake of said aircraft and including means for housing said parachute means at the end of the boom remote from the aircraft.

* * * * *